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FISH MANAGEMENT REPORT 143

FALL 1989

Bureau of Fisheries Management • Department of Natural Resources • Madison, Wisconsin 53707

A WALLEYE POPULATION MODEL FOR SETTING HARVEST QUOTAS

By
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PUBLICATION NOTE: This Fish Management Report is an edited version of information presented during 11 October - 2 November 1988 walleye and muskellunge management litigation between the State of Wisconsin and the six Wisconsin bands of Lake Superior Chippewa. On 3 March 1989, the federal court mandated the lower 95% confidence interval of this walleye population model to set quotas for efficient harvest methods. Thus, an estimated 2.5% of all lakes -- those with the lowest walleye population densities -- remain at risk of overexploitation. After the court order, sub-models of stocked and naturally reproducing walleye populations were also developed.

ABSTRACT

A walleye, Stizostedion vitreum vitreum, population model was developed to set quotas for efficient harvest methods, based on data from 104 lakes. A log-log correlation between lake area (acres) and adult walleye abundance (numbers) described 65% of the variation between these parameters. Average adult walleye population density increased from 3.4/acre for a 50-acre lake to 4.2/acre for a 15,000-acre lake. Potential exploitation using the mean regression value would be ≥35% in 1 of 2 lakes, ≥78% in 1 of 5, and 100% in 1 of 10. By contrast, potential exploitation using a lower 5% risk level would be ≤35% in 19 of 20 lakes. I recommend using a lower risk level to set quotas for efficient harvest methods, with complementary regulation of compensatory angling harvest. I also recommend developing sub-models based on recruitment sources to refine harvest quotas.

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INTRODUCTION

Recently, the federal court affirmed more extensive Chippewa off-reservation fishing rights than state laws had allowed -- legalizing increased harvests and intensive fishing methods in territory the Indians had ceded under 1837 and 1842 treaties. Now, state and tribal agencies are attempting to develop management plans to accommodate this off-reservation fishing.

Walleye, _Stizostedion vitreum vitreum_, speared during spawning runs, is the projected principal tribal harvest. Some harvest of other species (e.g., muskellunge and largemouth bass) will occur, and other methods (e.g., gill nets, trap nets, and seines) may become more popular.

As litigation proceeded, Chippewa off-reservation fishing followed interim annual agreements between state and tribal negotiators. During negotiations for the 1985-88 spring spearing seasons, an Inland Fisheries Technical Working Group (TWG) of DNR and tribal biologists determined systems for setting total allowable catches (TACs), permitting spearers, monitoring harvests, and so on.

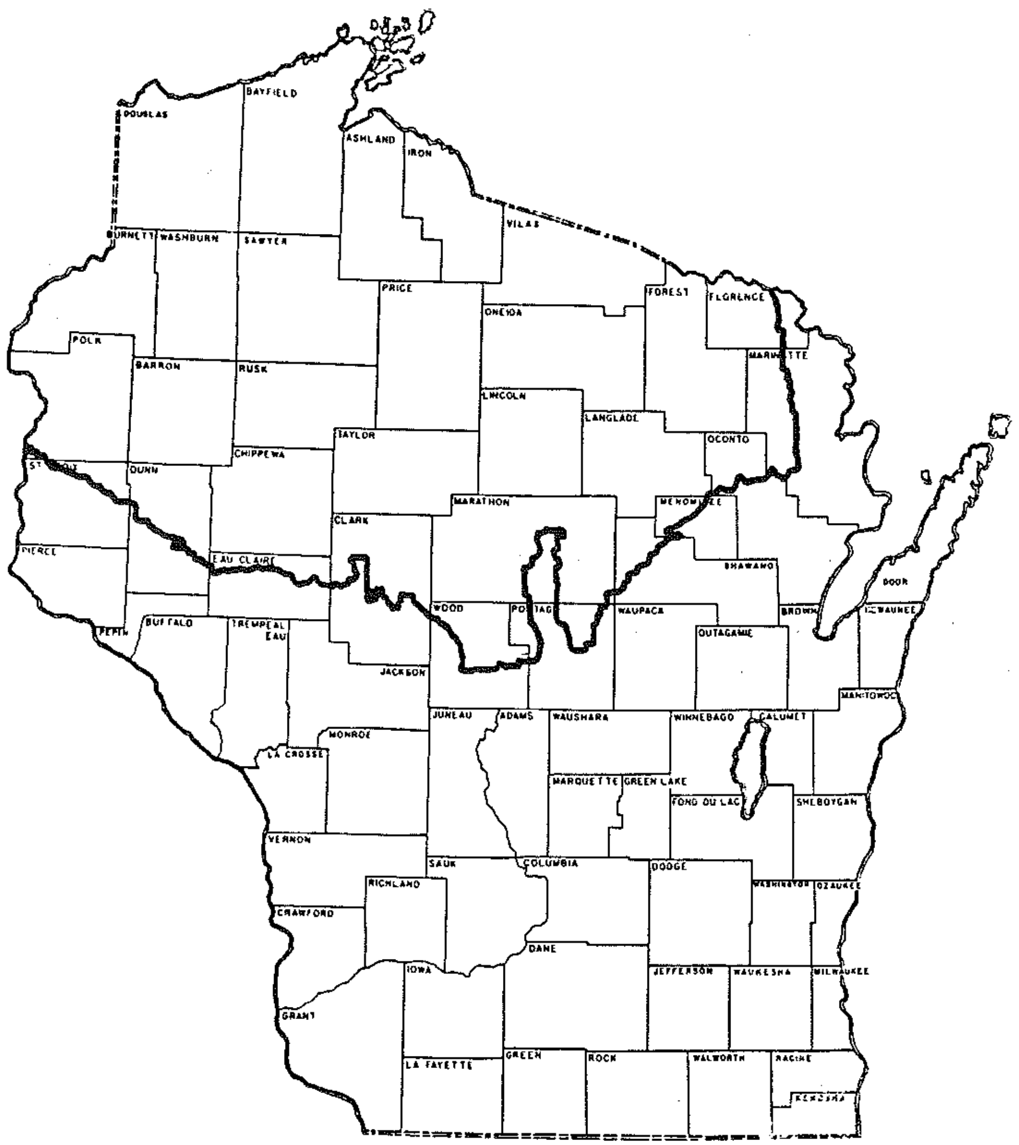
The system TWG originally established for setting TACs on lakes without walleye population data estimated abundance by using:

- -- the statewide average adult walleye population density (5.2/acre) or
- -- a comparable lake's adult walleye population density (usually a neighboring lake).

When used to set TACs for the 1985-87 seasons, the original system produced harvest quotas that were generally too high. Further analysis showed that the statewide average was too high, due to a skewed distribution of walleye population densities. Comparable lake estimates were also faulty.

TWG's DNR members established a new system for setting TACs using a log-log correlation between lake area (acres) and adult walleye abundance (numbers). The regression model was adopted for the 1988 season after review by TWG's full membership. This report summarizes the short-term risks of using the model to set harvest quotas.

STUDY AREA



The ceded territory in northern Wisconsin.

METHODS

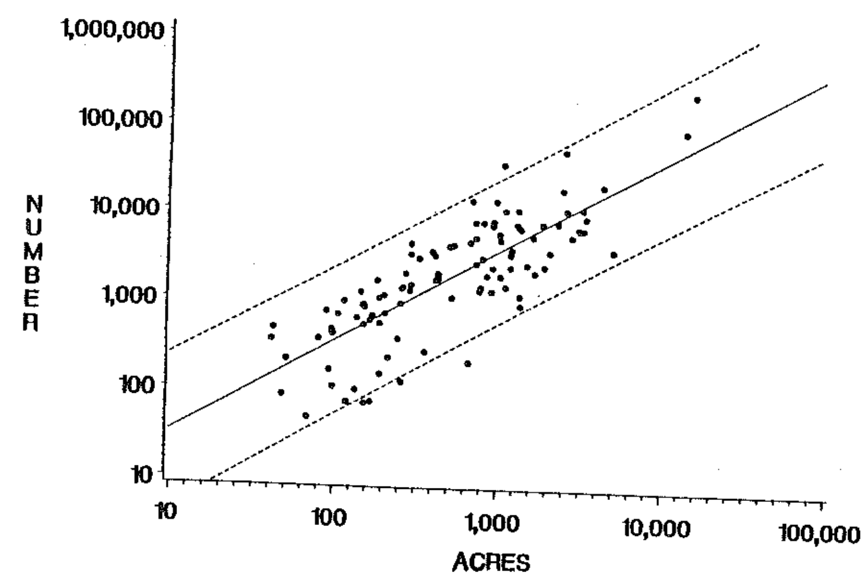
The Department of Natural Resources has conducted walleye population surveys since the 1950s, but these infrequently included adult population estimates. The standard method for determining such estimates is to mark fyke-netted (occasionally electro-fished) walleye during spring spawning runs, record recaptures during subsequent fyke-net/electro-fishing samplings or creel surveys, and apply Peterson or Schnabel extrapolations.

Based on the walleye population surveys, the Department of Natural Resources, preparing for Chippewa off-reservation fishing litigation, developed a computer file of lake names, master waterbody codes (Fago 1986), lake areas (acres), percentages of lake areas in the ceded territory, survey dates, population estimates, and estimate length or age ranges. TWG reviewed the file, focusing on adult walleye population estimates for lakes in the ceded territory.

During the review, TWG standardized length at $\geq$12 inches for adult walleye because recapture samplings within 1-2 days after marking generally gave unbiased estimates of adult stock whereas recapture samplings 2-3 weeks after marking gave overestimates. Conversely, when underestimates occurred in non-random (spawn collection) marking and recapture samplings, TWG substituted less-biased samplings or rejected the entry if acceptable substitutes were unavailable. For lakes with multiple acceptable estimates, TWG used the average to represent adult walleye abundance.

After the review, plotting the data in a log-log regression model (Fig. 1) correlated adult walleye abundance (numbers) with lake area (acres). Then, applying confidence intervals (Snedecor and Cochran 1967) and evaluating them proportionately below the mean -- i.e., for lakes with adult walleye abundance below average -- indicated the percentage of lakes remaining at risk of overexploitation given harvest quotas based on corresponding abundance levels. As the abundance levels used to set harvest quotas decrease, so do risk levels.

Figure 1. Regression model of adult walleye abundance against lake area.



RESULTS

The acceptable adult walleye population estimates for 104 lakes in the ceded territory included lakes ranging from <50 to >15,000 acres. The average was 520 acres -- with 1,931 adult walleye (3.7/acre).

There were acceptable adult walleye population estimates for 7% of lakes <500 acres in the ceded territory, but for 35% of lakes >500 acres. Furthermore, the estimates from lakes <500 acres disproportionately represented lakes >100 acres, which accounted for 81% of the estimates but only 57% of the actual lakes <500 acres. Similarly, the estimates from lakes >500 acres disproportionately represented lakes >900 acres, which accounted for 76% of the estimates but only 51% of the actual lakes >500 acres.

The model showed average adult walleye population densities ranging from 3.4/acre for a 50-acre lake to 4.2/acre for a 15,000-acre lake. These densities are 35% and 19% lower, respectively, than the statewide average density of 5.2/acre used to set 1985-87 TACs and tribal quotas. However, because spearing in those years was limited to lakes ≥500 acres, the minimum density was 3.7/acre, 29% below average.

The model described 65% of the variation in adult walleye abundance (Table 1). Adult walleye abundance (Table 2) and TACs (Table 3) below the mean regression were about 44% of the mean for 1 of 5 lakes, 29% for 1 of 10, 20% for 1 of 20, and 10% for 1 of 100. If TAC were estimated from the mean regression value (e.g., mean x 0.35), the exploitation rate would be ≥35% in 1 of 2 lakes, ≥78% in 1 of 5, and 100% in 1 of 10.

Table 1. Analysis of modeled adult walleye abundance data.

A. Analysis of variance.

Source	DF	Sum of Squares	Mean Square	F Value	Prob >F
Model	1	33.18326919	33.18326919	196.773	0.0001
Error	103	17.36963666	0.16863725		
C Total	104	50.55290584			

Root Mse: 0.4106547 Dep Mean: 3.28572 CV: 12.49816 R-Square: 0.6564 Adj R: 0.6531

B. Parameter estimates.

Variable	DF	Estimate	Error	Parameter = 0	Prob >|T|	Label
Intercept	1	0.47126646	0.20460040	2.303	0.0233	Intercept
Logarea	1	1.03637848	0.07388147	14.028	0.0001	Log10area

Table 2. Adult walleye abundance in various-sized lakes. (Percentages indicate lakes with below average abundance, and thus describe risk levels.)

Area	50%	20%	10%	5%	1%
100	350.0	155.6	101.7	71.30	35.13
200	717.8	320.6	210.0	147.50	72.95
300	1,092.7	488.8	320.4	225.18	111.52
400	1,472.3	658.9	432.1	303.74	150.50
500	1,855.3	830.5	544.7	382.90	189.74
600	2,241.2	1,003.2	657.9	462.49	229.18
700	2,629.4	1,176.8	771.7	542.43	268.75
800	3,019.7	1,351.2	885.9	622.65	308.43
900	3,411.8	1,526.1	1,000.5	703.10	348.20
1,000	3,805.4	1,701.7	1,115.5	783.75	388.03
1,500	5,792.9	2,586.1	1,693.7	1,189.15	587.88
2,000	7,805.2	3,478.6	2,276.2	1,596.95	788.32
2,500	9,836.0	4,376.8	2,861.5	2,006.25	989.01
3,000	11,881.7	5,279.4	3,449.0	2,416.58	1,189.77
3,500	13,940.0	6,185.6	4,038.1	2,827.65	1,390.51
4,000	16,009.0	7,094.6	4,628.5	3,239.27	1,591.16
4,500	18,087.4	8,006.2	5,220.0	3,651.31	1,791.71
5,000	20,174.3	8,920.0	5,812.3	4,063.68	1,992.11
6,000	24,370.3	10,753.2	6,999.3	4,889.12	2,392.47
7,000	28,591.9	12,592.5	8,188.5	5,715.19	2,792.17
8,000	32,835.6	14,437.0	9,379.6	6,541.65	3,191.21
9,000	37,098.7	16,285.9	10,572.2	7,368.31	3,589.58
10,000	41,379.0	18,138.6	11,765.9	8,195.07	3,987.29

Table 3. TACs on various-sized lakes. (Percentages indicate lakes with below average abundance, and thus describe risk levels.)

Area	50%	20%	10%	5%	1%
100	122.5	54.47	35.60	24.95	12.30
200	251.2	112.21	73.51	51.62	25.53
300	382.4	171.08	112.16	78.81	39.03
400	515.3	230.63	151.25	106.31	52.67
500	649.4	290.69	190.65	134.01	66.41
600	784.4	351.13	230.28	161.87	80.21
700	920.3	411.88	270.10	189.85	94.06
800	1,056.9	472.90	310.08	217.93	107.95
900	1,194.1	534.15	350.19	246.08	121.87
1,000	1,331.9	595.60	390.41	274.31	135.81
1,500	2,027.5	905.15	592.79	416.20	205.76
2,000	2,731.8	1,217.52	796.66	558.93	275.91
2,500	3,442.6	1,531.89	1,001.54	702.19	346.15
3,000	4,158.6	1,847.80	1,207.15	845.80	416.42
3,500	4,879.0	2,164.94	1,413.34	989.68	486.68
4,000	5,603.1	2,483.12	1,619.97	1,133.75	556.91
4,500	6,330.6	2,802.18	1,826.99	1,277.96	627.10
5,000	7,061.0	3,122.01	2,034.32	1,422.29	697.24
6,000	8,529.6	3,763.60	2,449.75	1,711.19	837.36
7,000	10,007.2	4,407.38	2,865.99	2,000.32	977.26
8,000	11,492.5	5,052.96	3,282.87	2,289.58	1,116.92
9,000	12,984.7	5,700.07	3,700.26	2,578.91	1,256.35
10,000	14,482.7	6,348.52	4,118.07	2,868.28	1,395.55

DISCUSSION

The model indicates adult walleye population densities 19-35% below the statewide average adult walleye population density. Thus, the statewide average, used to determine 1985-87 TACs, estimated densities 19-29% too high for lakes ≥500 acres. Moreover, this bias was 56% higher for about 1 of 5 lakes with below average densities -- 71% higher for 1 of 10, 80% higher for 1 of 20, and 90% higher for 1 of 100.

The model enables harvest quotas to be set at known risk levels. For example, quotas set using the mean regression value yield exploitation rates ≥35% in 1 of 2 lakes. Conversely, quotas set using a 5% risk level yield exploitation rates ≤35% for 19 of 20 lakes. Thus, using the mean regression value places 1 of 2 lakes at risk of overexploitation, while using the 20% risk level places 1 of 5 at risk, and so on.

Risk of overexploitation depends on the harvest method -- either a compensatory force, such as hook-and-line angling, or a non-compensatory force, such as spring spearing. Data on hook-and-line angling indicate average adult walleye exploitation rates <35%. Similarly, during 1985-88 spring spearing, adult walleye exploitation rates were <35% where regulated at 20% tribal quotas of the 35% TACs. However, higher tribal quotas put many lakes at risk of overexploitation. How much angling will be compensatory with spearing is unknown.

Further analysis of adult walleye abundance may indicate sub-sets of lakes with below average population densities. Stocked lakes, for example, with below average densities of about 1.5/acre (GLIFWC 1988), could form such a sub-model. Quotas could then be set using lower risk levels that better protect lakes with below average population densities.

MANAGEMENT RECOMMENDATIONS

I recommend the following:

1. Use the model's lower confidence limits to set harvest quotas at lower risk levels.

Although the model reduces bias in estimating adult walleye abundance, each population estimate remains subject to error. Moreover, because the model does not differentiate for varied populations among same-sized lakes, using the mean regression to set harvest quotas may protect lakes with above average adult walleye population densities, but not those below average. Also, the risks to fisheries from a single year of overexploitation compound through time.

2. Regulate hook-and-line angling to complement spearing.

When the model was used to set harvest quotas on mixed fisheries during 1988, 20% of TAC was allocated to spring spearing -- 80% to hook-and-line angling. In no lake was TAC exceeded by spring spearing alone, though overexploitation from the combined methods occurred on several lakes.

A proposed method of setting tribal quotas for lakes without current population data would use the model to: 1) estimate adult walleye abundance, 2) set TAC at 35% of the estimate, and 3) set the tribal quota at 20% of TAC. This method is about equivalent to setting TAC at the 5% risk level and allocating the entire TAC to the tribal quota. Any hook-and-line angling, then, would put 1 of 20 lakes -- or roughly 43 of the 861 walleye lakes in the ceded territory (Staggs 1989) -- at risk of overexploitation in a single year. Of these lakes, 9 are >500 acres (171 lakes total) and 34 are <500 acres (690 lakes total).

Using the model to set tribal quotas for lakes with below average adult walleye population densities depends on the compensatory nature of hook-and-line angling. While 20% angling reductions may protect lakes with average population densities, below average lakes would need further reductions based on the interrelationship between angling and adult walleye abundance. If angling is proportional to abundance, then angling can be regulated with an equivalent reduction -- if not, then angling must be regulated accordingly.

3. Develop walleye lake classifications.

Sub-models for different classes of walleye lakes could more precisely describe the correlation between lake areas and adult walleye abundance, thus enabling: 1) more precise TACs and harvest quotas, and 2) less management risk.

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ACKNOWLEDGMENTS

I thank Michael Staggs for his technical advice and cooperation during development of the walleye population model. Numerous past and present employees of the Wisconsin Department of Natural Resources collected data for the model. Without their hard work and diligence, this model would not have been possible. I also thank Kendra Nelson for editing this report based on trial records.

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